OCEANOGRAPHIC REPORT FOR COASTAL ZONE STUDY

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I. GENERAL DESCRIPTION OF THE GULF OF MEXICO

Occupying a surface area of 619,000 square miles, the Gulf of Mexico is roughly two and one-thirds times the size of the State of Texas. Although almost entirely surrounded by land (of the United States, Mexico, and Cuba), the Gulf exhibits fully marine conditions; and, because of its small size, it provides a unique opportunity for studying a total marine system as a functional unit. For practical purposes, the Gulf may be divided into three zones: the *coastal zone*, *continental shelf*, and *offshore area* or *deep Gulf* (Figure 1). Although characterized by different properties and resource potentials, these three zones are intimately interrelated in the sense that they exchange water masses, nutrients, and living organisms.

Coastal Zone

The coastal zone includes bays, estuaries, lagoons, and other shoreline features which are generally characterized by *shallow water, low but variable salinity,* and *reduced tidal action.* These areas often receive inflow from streams, on the one hand, and from the Gulf, on the other. Much sedimentary material is deposited here so that the bottoms tend to be quite muddy. *Such areas are normally zones of intense biological activity.* Bacteria and other decay organisms break down the organic material transported from elsewhere as well as the organic matter produced locally, especially in the salt marshes. Large populations of juvenile fish, crustaceans, and mollusks utilize these areas as nursery grounds and feed largely upon the nutrient-rich decaying organic matter of the shallow backwaters. *Thus, the production of most of the species of commercial importance (shrimp, crabs, oysters, menhaden, etc.) is tied closely with the water quality of the nursery areas.* Any activities which diminish the inflow of fresh water, reduce the extent of the salt marshes, or lower the quality of the estuarine waters are likely to decrease the populations and, hence, the potential harvest of the coastal marine biological resources.

Continental Shelf

The continental shelf extends from the shoreline out to a depth of about 600 feet. Along the Texas coast it varies in *width from 40 to 120 miles.* The shelf receives water from land drainage (through the outfalls of streams, estuaries, etc.), from the open Gulf, and from neighboring portions of the shelf (by long-shore currents). *The environment of the shelf exhibits regular patterns of seasonal variation, but conditions may vary widely from year to year in response to water currents and weather*

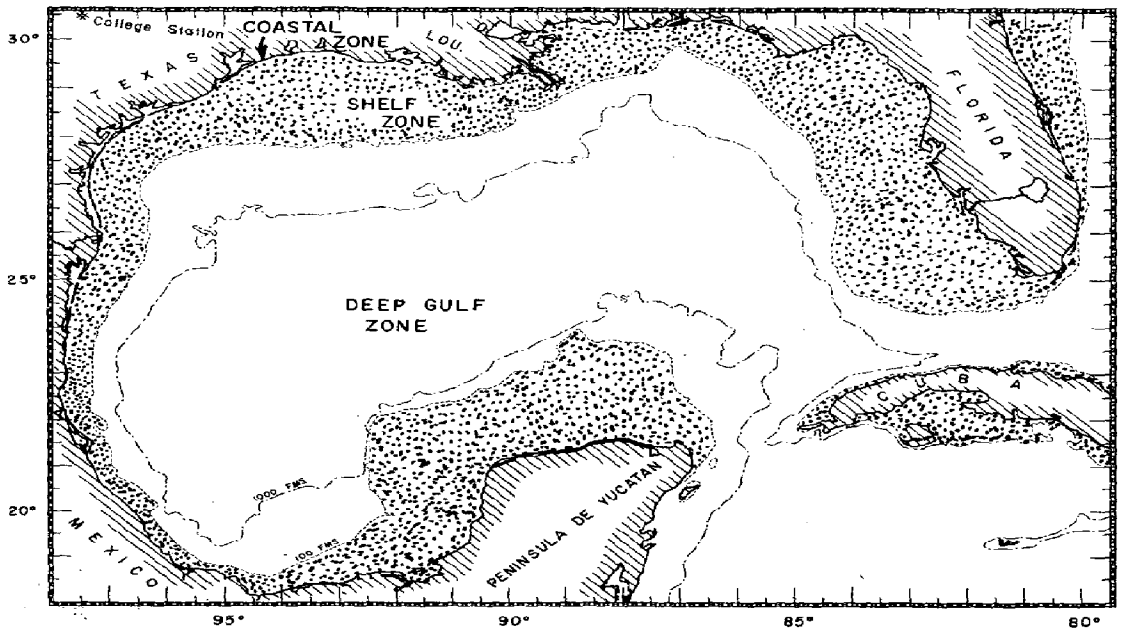

Figure 1. Map of the Gulf of Mexico showing the three zones.

patterns. Along the northern Gulf coast, the nearshore environments tend toward high mud content, whereas sand and shell bottoms increase with distance from shore. Consequently, nearshore waters contain much suspended matter and are highly turbid, while offshore waters have little suspended matter and are clear and deep blue. Along the outer edge of the continental shelf lie a *number of hills* which approach within a hundred feet of the surface. These hills support marvelous reefs of coral and carbonaceous algea which are populated by highly colored fishes and invertebrates of West Indian affinity.

Deep Gulf

Beyond the edge of the continental shelf lies the bulk of the Gulf of Mexico covering a surface area of about 500,000 square miles and achieving a depth of 2 1/2 miles. *This area is characterized by clear water and low biological productivity, and the environment tends to be less variable than the shallower zones.* The deep Gulf is horizontally stratified. The surface water to a depth of about 150 feet is lighted and of relatively high temperature (approaching 90° F. at the surface in mid-summer), whereas the bottom water is totally devoid of light and exhibits year-around temperatures only a few degrees above freezing. This stratification is reflected in the distribution of the chemical and biological components of the deep Gulf. All three zones of the Gulf of Mexico *probably contain exploitable quantities* of petroleum and other geochemical resources.

II. EXTERNAL INFLUENCES

Although occupying a semi-enclosed basin, the Gulf of Mexico is strongly influenced by three major external factors:

the Yucatan current,

drainage from land, and

atmospheric factors.

These three influences determine, in large measure, the special characteristics of the Gulf and are chiefly responsible for the dynamic balance between the living and non-living components of the Gulf system.

Yucatan Current

The Yucatan current annually brings approximately *200,000 cubic miles of water* into the Gulf of Mexico from the Caribbean Sea. This tropical water is distributed through both the surface

and bottom layers of the Gulf and serves to keep the water os the Gulf of Mexico in circulation. Since the incoming waters are highly oxygenated, they maintain oxygen-rich conditions in the Gulf from top to bottom. *Without this constant flushing action, the Gulf of Mexico would tend to develop conditions of stagnation* (as occurs in the Black Sea and portions of the Mediterranean). The Yucatan current is also responsible for transporting tropical species so that the fauna and flora of the Gulf of Mexico are closely related to the Central American and West Indian biota. The Gulf is *drained* by currents passing into the Atlantic Ocean through the Straits of Florida.

Land Drainage

The Gulf of Mexico receives drainage from most of the United States lying between the Rocky Mountains and the Appalachians, as well as from eastern Mexico and a small portion of northern Cuba. *Nearly a million cubic feet per second of fresh water are normally discharged into the Gulf*, about three-quarters of which derives from the Mississippi-Atchafalaya River systems. Since the prevailing current along the ocntinental shelf of the northern Gulf is westerly, much of the sedimentary discharge of these streams is deposited along the Louisiana-Texas shelf areas. These streams drain most of the important agricultural lands and much of the highly industrialized portion of the United States so that the stream run-off (estimated to be about one-fourth of the total precipitation volume) brings into the Gulf enormous *quantities of fertilizers, pesticides, and other dissolved and suspended by-products of human activities*. Thus, the Texas coastal waters receive large amounts of domestic, agricultural, and industrial residues from the entire mid-section of the United States. The exact nature and extent of this pollution and its effect upon the coastal resources is *yet* to be determined.

Atmospheric Factors

The Gulf of Mexico is influenced by atmospheric conditions arising from the North American continental land mass (especially in the winter) and from the Caribbean area (especially during the summer). During the winter, cold, high-pressure Canadian air sweeps across the central plains bringing northern storms all the way to the Gulf, chilling the estuaries, and creating surface disturbances in the Gulf which send high rolling waves all the way to Yucatan. During the warmer months, tropical storms originating farther south sweep into the Gulf from the Caribbean. During the late summer, when the surface waters of the Gulf of Mexico achieve temperatures in excess of 85%F., they may provide the energy to transform tropical storms into hurricanes which strike the northern Gulf Coast with devastating force.

III. STATE OF OUR KNOWLEDGE OF THE GULF OF MEXICO

Despite the extensive coastline and great economic potential *the Gulf of Mexico has not been the subject of intensive investigation until the past two decades*, and thus, even though a fair amount of pertinent information has been amassed in recent years, the system as a whole is only partially understood. This lack of knowledge is due to a combination of factors.

Serious marine investigation requires *adequate laboratory facilities on land* to process the marine data; to house collections of marine life, geological cores, and seawater samples; to study volumes of data on water current patterns and weather conditions; and to carry out a variety of chemical and physical analyses as well as laboratory experiments. It requires *sophisticated electronic environmental monitoring equipment*, a variety of types of collecting gear, remote sensing devices, radioisotope analysis facilities, etc. Most of all it requires a *team of well-trained scientists* to design and build the equipment, to carry out the observations and experiments, and to interpret the data. It depends, further, upon a *team of dedicated supporting personnel* to operate the ships in all kinds of weather, to participate in the heavy physical labor associated with the collection of data at sea, and to aid in the conduct of laboratory analysis.

Major marine work is, thus, a long-term endeavor of acquiring facilities, building teams, and obtaining stable sources of continuing funds. *It must be a goal of society, free from political whim, and untrammeled by trivia.* To the credit of the State of Texas these conditions are now being met, and the goals are being achieved at Texas A & M University.

Until recently, however, most of the Gulf work was carried out by *the heroic individual* who operated from totally inadequate shore facilities; who sampled from a skiff, bay-boat, or shrimp trawler; and whose efforts were limited largely to bays, estuaries, and other nearshore environments. The studies were poorly funded, limited in scope, and generally of little direct economic importance. *Most of the applied work was carried out under contract, and the results were buried in the files of Government agencies and private industry.*

The state of our knowledge of the Gulf of Mexico was summarized in 1954 in a large report by the U. S. Fish and Wildlife Service (*Gulf of Mexico, Its Origin, Waters, and Marine Life*. Ed. by P. S. Galtsoff. See References section). Providing for the first time a comprehensive view of the Gulf system, this volume dramatically illustrated the extreme diversity and complexity of the system, and at the same time it pointed to the great paucity of information, especially concerning the shelf and offshore areas of the Gulf.

Since publication of this volume much has been learned about the system. Coastal features have been studied by several Federal

agencies, notably the Army Corps of Engineers, and significant reports are on file in their offices. During the 1950's the American Petroleum Institute sponsored an extensive series of investigations on the sedimentary environments of the northern Gulf coast, and these studies devoted considerable attention to the Texas coast. The U. S. Fish and Wildlife Service has conducted a series of exploratory fishery investigations on the deeper portions of the Texas shelf, the results of which are published primarily in the *Fishery Bulletins* and *Special Scientific Reports - Fisheries*. In addition, private industry has amassed a wealth of information concerning the potential mineral resources as well as the general surface and subsurface characteristics of the bays, estuaries, and continental shelf, but this information *is not generally available for public use.*

The most useful and most readily available information concerning the *offshore areas and the functioning Gulf system,* as a whole, has been amassed by and in cooperation with the Oceanography Department of Texas A&M University, and this information is available in the various publications and Reports of the Department (See Reference section.). These major studies fall into six categories, each of which is discussed briefly below.

Biological Oceanography treats the composition, distribution, abundance, and life histories of the marine organisms. Special efforts are being made to provide information on the abundance of marine production in relation to the physical and chemical environments of the Gulf. Studies are also underway on the effects of pesticides and other pollutants on marine species of economic importance.

Chemical Oceanography attempts to define the organic and inorganic chemicals found in the Gulf and to relate these materials to the overall chemical cycles of the sea. Both natural and man-made chemicals are under study, and efforts are being made to relate these to their sources of origin.

Geological Oceanography concerns the origin, transport, distribution, and properties of sedimentary materials in the Gulf of Mexico. It also attempts to describe the bottom surface features including slopes, canyons, salt domes, etc.

Geophysical studies involve exploration of the physical properties of the sediments and crustal rocks underlying the Gulf of Mexico and the surrounding basin and the interpretation of these structures in terms of the geological history of the region.

Meteorological studies are concerned with energy exchange across the air-sea interface. Involved is the investigation of wind-driven oceanic circulation and the effects of the oceanic system on weather phenomena, including the weather patterns on land as affected by oceanic disturbances.

Physical Oceanography deals largely with circulation patterns, thermal structure, tides, and surface wave patterns of the Gulf. Both meteorological and physical oceanography are being pursued at sea as well as through computer modeling experiments on land.

Studies listed above are being carried out in all three zones of the Gulf, the estuaries, the shelf, and the deep Gulf. Yet the task is one of some magnitude. For example, nearly *500 species* of fishes alone are already known from the Texas coast, and this figure represents less than half the types of fishes known from the entire Gulf. Add to this the thousands of types of tiny plants (algae) and invertebrates which inhabit the Gulf, and the diversity is staggering. Each type of organism displays its unique pattern of life in response to the currents, temperature, light, chemical factors, and other organisms, and each affects the environment in certain unique ways. There are, however, common denominators and overall patterns which can be discerned through careful study. *Efforts are already underway to understand the Gulf as a single functional system (in the ecological sense) through which chemicals and energy flow in regular pathways and at measurable rates.* Only through such basic knowledge can the resources of the Gulf be inventoried, managed, and utilized in a knowledgeable way.

IV. RESOURCES OF THE GULF

The Gulf of Mexico is a great regional asset. Its *exploitable mineral resources* include petroleum, sulfur, and natural gas (of the subsurface formations), sand and shell (of the surface), as well as a variety of chemical elements extractable from the seawater itself. *Biological resources* include a variety of fish, shrimp, crabs, and mollusks; and in 1969, the Gulf fisheries industry of the United States alone contributed a catch worth *152 million dollars* (about 30% of the total dollar value of the U. S. fisheries production that year). Many species which are not currently being utilized are potentially harvestable for direct human food, animal food, fertilizer, of FPC (fish protein concentrate). These include tunas, mackerel, pompano, deep-water shrimp, and a variety of smaller fish and crustacean species. Many of these forms are also available for potential commercial rearing ventures (mariculture). *The potential harvest of the Gulf biological resources is reflected in the fact that Cuba is building up a large and sophisticated fishery fleet.** In this connection, the *Russian* investigators have been intensively studying the fishery potential of the Gulf of Mexico (including the Texas coast) and *have recently published a book devoted entirely to this subject. While Texas debates the fishery potential, Cuban and Russian trawlers may be exploiting*

**Undoubtedly with Russian support and backing*

the resources on the Texas coast. In addition, it is known that *Japanese* long-line fishermen occasionally visit the Texas coast to harvest the tuna fishes of our shelf waters.

The Gulf of Mexico serves as a *transportation route* for marine shipping, and the availability of deep-water ports has fostered the development of much industry along the coast. The Gulf has been utilized as a *dumping site* for many of the solid wastes of civilization (including an arsenal of explosives) and as a *sump* for many of the liquid wastes. *As pressure is exerted to clean up the streams and the land of the nation, pressure will grow to use the Gulf as the final repository.*

Finally, the year-around mild climate of the Texas coast and the associated *recreational opportunities* have attracted many citizens who make use of the Gulf occasionally or indirectly. The coastal zone is visited by many citizens of the coastal and inland states. As California and Florida become saturated with humans seeking employment opportunities and retirement homes, the Texas coast will undoubtedly feel the effects of heavy population influx. While contributing to the economic base of the coastal areas, they *will exert further pressure* on the coastal and shelf zones of the Gulf itself.

It is clear that the conflicting uses of the Gulf resource must be brought into *proper perspective.* Yet it is already obvious that we are *exploiting and polluting an essentially unknown resource* and that the intensity of use and abuse will increase with greater human settlement and technological development. The Texas coast is already feeling the effect of oil pollution and of continental pesticide utilization, and *the question may legitimately be asked as to whether the biological resources of the Gulf will continue to be fit for human consumption or whether, indeed, they will even continue to exist as the toxic non-degradable wastes accumulate.* To those attempting to study the Gulf, the need for more detailed knowledge is as obvious as the need for planning.

Within the immediate future, the main pressure will be directed to the estuaries and the shelf. Yet one can not hope to understand either the estuaries or the shelf through superficial surveys of standing stocks or of pesticide analyses of occasional marine organisms. The resources of the Gulf are intimately interrelated; and to understand these relationships, *one must develop the theoretical framework upon which practical decisions may be based.* Of cardinal importance is the knowledge of the biological, chemical, and sedimentary characteristics of each water mass bathing the coast. With this knowledge as background, multi-disciplinary inventories will provide the base-lines against which pollution and exploitative effects may be measured.

V. FILLING THE GAPS

Research supplies the basic data upon which planners and legislators must ultimately rely to reach appropriate decisions concerning multi-use resources. To bring the present discussion into the kind of focus necessary for planning and legislative decision-making there is set down below a series of concrete problems which merit immediate attention.

1. *Air-water interactions* - One of the most basic needs relates to the understanding of the complex water currents of the Gulf of Mexico, the factors which underlie them, and the ways in which the water currents interact with air patterns to produce the variable and often severe weather of the coastal zone. This knowledge is of fundamental importance in planning for shipping, agriculture, recreation, and dense human settlement in the coastal zone. Such knowledge also must underlie our understanding of the functional biological systems of the Gulf as well as the distribution and effects of coastal pollution, oil spills, etc.

2. *Inventory of mineral resources* - Since most of the information concerning the potential mineral resources of the Gulf is not available to the public some effort to survey these resources should be made by the State. The survey should give some attention to the subsurface deposits (oil, gas, sulfur, etc.) as well as the surface deposits of harvestable sand and shell. Associated with these investigations other studies should be carried out to determine methods of exploitation which would *cause the least damage* to the biological resources of the overlying water.

3. *Inventory of biological resources* - There is a strong and immediate need for a thorough inventory of the marine biological resources of the Texas shelf and adjacent waters. This study should be coupled with a detailed analysis of *how the ecological system actually works*. Such studies are necessary to lay the groundwork for wise management of the harvestable biological resources, *but they also are important in establishing the base-lines against which pollution damage may be assessed. Herein lies the URGENCY.*

4. *Survey of present extent of Gulf pollution* - There exists a desperate need to determine the extent to which the various areas of the Gulf are *already* damaged by pollution. On almost every oceanographic cruise the scientists encounter *oil slicks* on the surface. Cables, ropes, and equipment often come up oily. Bottom samples retrieve all manner of *human debris* from tin cans to metal gun

shell casings. Mounting evidence of *pesticide and heavy metal* pollution of the bays and estuaries suggests that the environment of the continental shelf may also be subject to pollution pressure, and it is of utmost importance to initiate an in-depth survey of pollution damage to the environment and ecosystem of the shelf zone.

5. *Studies to predict future dangers* - Investigations should be carried out in both the laboratory and the field to predict the effects of intensive coastal zone utilization and water resource modification on the Gulf system, and *particularly on the harvestable biological resources.* In order to complete their life cycles most of our commercially important fish and shellfish species require low salinity waters of high quality as well as estuarine bottoms which are constantly refertilized by the silt load derived from *normal* stream discharge. Construction of the Aswan dam in Egypt *has devastated* the fishery industry of the eastern Mediterranean, and it is *possible* that the State of Texas can accomplish the same result for its Gulf fishery if the coastal zone is deprived of its normal flow of nutrient-laden fresh water.

6. *Establishment of marine wildlife sanctuaries* - Up until the present time the living resources of the Gulf *have been taken for granted.* With intensive pressure from human coastal activities, however, the marine life will need help to survive. If survival of marine life is important to the well-being and happiness of the human population immediate steps should be taken to establish a series of marine and coastal wildlife sanctuaries where the marine organisms may exist in perpetuity. Such sanctuaries would be of considerable recreational value, but they would also serve as a source from which more devastated areas could be restocked.

It is specifically recommended that *San Antonio Bay* and *Matagorda Island,* which are still in fairly primitive condition, be designated as a sanctuary to accompany and protect the birds and other wildlife of the Aransas Wildlife Refuge. It is also recommended that steps be taken to preserve Texas' only major living coral reef, the *Flower Gardens,* located on knolls at the outer edge of the continental shelf (about 120 miles southeast of Galveston). As the northernmost living coral reef of the western Atlantic these undersea gardens are of considerable scientific interest and of potential recreational value. *Unfortunately, this is also a convenient spot for ships to anchor while cleaning out their tanks before proceeding into the Port of Galveston.* Damage from anchors, garbage, and tank refuse is mounting.

7. *A synthesis of our knowledge of the Gulf* - Knowledge of the Gulf of Mexico is not readily available to the planner, legislator, industrialist, educator, sportsman, and general reader. Furthermore, even the oceanographer has a firm grasp of only the *limited* portion of the subject with which he is working. As an aid in future planning and as a service to the public, the State of Texas should authorize and finance an endeavor to provide a sourcebook on the Gulf of Mexico which is both authoritative and readable. The potential authors of this book *are already present* in the State.

APPENDIX

MAJOR SOURCES OF REFERENCE LITERATURE CONCERNING

THE GULF OF MEXICO

A. *General Sources* (containing a variety of types of information)

1. Books

Galtsoff, P. S. (Ed.) 1954. Gulf of Mexico, Its Origin, Waters, and Marine Life. U. S. Fish & Wildlife Service, Fishery Bulletin, 55. 604 pp.

Ladd, H. S. (Ed.) 1957. Treatise on Marine Ecology and Paleoecology. Geological Society of America Memoirs. 67, Part 1. Ecology. 1296 pp.

2. Journals

Deep Sea Research

Journal of Marine Research

Limnology and Oceanography

3. University Series

University of Miama (Florida)

- "Bulletin of Marine Science of the Gulf and Caribbean"

Louisiana State University

- Coastal Studies Institute - "Technical Report" Series

University of Texas

- "Contributions in Marine Science"

Texas A&M University - Department of Oceanography

- "Contributions in Oceanography"

- "Folio Series on the Gulf of Mexico" (Publ. by the American Geographical Society).

- "Technical Reports" Series

- "Texas A&M Oceanographic Studies" (Publ. by the Gulf Publishing Company, Houston, Texas).

B. *Journals Related to Specific Fields*

1. Biological

U. S. Fish and Wildlife Service, Fishery Bulletins

U. S. Fish and Wildlife Service, Special Scientific Reports - Fisheries

2. Chemical

Geochimica et Cosmochimica Acta

3. Geological

American Association of Petroleum Geologists, Bulletin

Gulf Coast Association of Geological Societies, Transactions

Journal of Geology

Marine Geology

4. Physical and Geophysical

American Geophysical Union, Transactions

Journal of Geophysical Research

THE MULTI-USER ZONE OF THE GULF OF MEXICO --ITS PROMISE AND PROBLEMS[1]

Richard A. Geyer[2]

INTRODUCTION

There is an ever increasing intensification of the use of the coastal zone as the expanding population of the United States moves into this area. Currently, seventy percent of the Nation lives within an hour's drive of the sea coast, if the Great Lakes are included. A decent concern to preserve life's amenities, as well as economic considerations demand that more adequate provision be made for recreational use along the Nation's crowded coastal zone. It may come as a surprise that this emphasis on the recreational use of this zone should come so early in this discussion when one realizes the critical industrial uses that exist in this area as well. A comparison of recreational activity in coastal and offshore areas is summarized in Table 1. However, if the citizens of the highly congested urban areas along the sea coast do not have clean and attractive areas for recreational pursuits then many of the severe urban problems which face us today will never be solved completely and satisfactorily. In addition, private housing has exercised and will continue to exercise one of the greatest demands for available shore property. This is demonstrated, for example, in the Boca Ciega bay area off the West Coast of Florida. It has been transformed completely by housing developments and related activities in the past twenty years. The same applies to several areas along the Gulf Coast. But there are other needs that must be met. Traditionally heavy industry is located on the water's edge in seeking a cheap source of transportation for its finished products as well as ready access to raw material and a simple solution to waste disposal problems. Pollution abatement requirements have lessened somewhat the economic desirability of a waterfront industry location, but recent trends in

TABLE 1. A Comparative Summary of Recreational Activity in Coastal and Offshore Areas

	Participants, millions		Annual expenditures, millions of dollars	
Type of recreation	1964	1975	1964	1975
Swimming	33.0	40.0	$1,500	$2,000
Surfing	1.0	4.0	50	200
Skin Diving	1.0	3.0	300	900
Pleasure Boating	9.6	14.0	650	1,000
Sport Fishing	8.2	16.0	760	1,300
Total	52.8	77.0	$3,260	$5,400

Source: Battelle Memorial Institute, *A Study of the U.S. Coast and Geodetic Survey's Products and Services as Related to Economic Activity in the U.S. Continental-Shelf Regions*, April 1966.

[1]Paper No. 70052 of the Water Resources Bulletin (Journal of the American Water Resources Association). Presented at the Fifth American Water Resources Conference, San Antonio, Texas, October, 1969. Discussions are open until six months from date of publication.

[2]Head, Department of Oceanography, Texas A&M University, College Station, Tex.

shipping have increased the demand for deep water frontage. Deep water access will be essential to the future competitiveness of steel and other U.S. industries processing large volumes of heavy raw material. Similarly, future shoreline development must provide adequately for additional transportation and power generating facilities. For almost a hundred years a vast network of piers, warehouses, and railroads was constructed about the perimeters of the Nation's ports, as seen in Figure 1. Today these facilities and housing to handle the type ship shown in Figure 2, as well as major offshore unloading facilities for deep draft tankers are shown in Figure 3. This transition will be extraordinarily difficult and will require considerable planning and coordination of public and private activities on an entirely new scale.

Electric power production has doubled approximately during every decade of this century. An increasing percentage of new power plants will use nuclear fuel; disposition of waste heat will become an increasing problem. An example of such a combined power and desalination plant designed for the Los Angeles area is shown in Figure 4. It is estimated that by 1980 the power industry will use for cooling one-fifth of the total fresh water run-off of the United States. Many more power plants will be located along the shore, thus competing not only for valuable land but warming the local waters posing a major threat to the regional ecological balance.

This is especially serious when we consider that seventy percent of the present U.S. commercial fishing effort takes place in coastal waters. Coastal and estuarine waters and marsh lands provide the nutrients, nursing areas, or spawning grounds for two-thirds of the world's entire fishery harvest. Seven of the ten most valuable species in American commercial fisheries spend all or important periods of their lives in estuarine waters; and at least 80 other commercially important species are dependent upon estuarian areas. Thus, not only thermal pollution but other types of pollution present an ever increasing threat, together with land fillings, dredging, dumping, and marsh draining operations to these areas. For example, eighty percent of the 300 square miles of tidal wetlands originally surrounding San Francisco Bay have been filled. Coming closer to home, 68,000 of the 828,000 prime acres of estuaries for the state of Texas or eight percent of this habitat has been lost. Of the other states bordering the Gulf, namely, Louisiana, Florida, and Mississippi, the percentages lost to date are 3, 8, and 2 percent respectively. Although one might say this compares favorably with the sixty-seven percent lost to California, and fifteen percent to New York and New Jersey, the impact on the fishing industry can be substantial when the pollution aspects as well are also considered.

Although aquaculture today as shown schematically in Figure 5 is of relatively minor importance in the coastal zone, its future in this area will continue to grow. As it does, the problems of conflicting use will increase; and estuarian areas leased for this purpose may be closed to sports fishermen and in some cases to navigation. A state wishing to emphasize the development of a major program in aquaculture may be compelled to limit its shore-side industrial development, or visa versa. Similarly, the conflict between competing objectives such as navigation, flood control and aquaculture is also a real one, as for example in the case of the Bonnet Carre Spillway located on the Mississippi River near New Orleans. Opening this spillway occasionally in the interests of flood control results in vast volumes of fresh water diluting the salinity of large areas to the extent that the oyster industry could be affected under certain conditions.

The expanding use of merchant as well as military shipping in the Coastal Zone, particularly the use of very large super tankers soon will require the designation of reserved fairways. The introduction of high speed hovercraft and hydrofoils will call for new safety measures, not to mention the burgeoning expansion of power boats and sailboats and their attendant marinas will be competing to an ever increasing degree in this zone.

DEFINITION AND STATISTICS OF COASTAL ZONE COMPONENTS

The Coastal Zone is a region of transition between two environments--the land

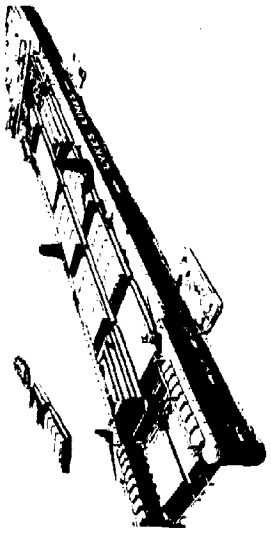

Figure 2

Figure 4

Figure 1

Figure 3

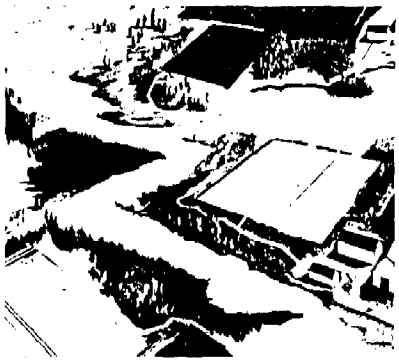

Figure 5

and the sea. It may be defined as that part of the land affected by its proximity to the sea. It includes a total of 1,631 statute miles along the Gulf Coast. The associated estuarine areas along the Gulf of Mexico include 3,838 square miles. This area is based on a definition of an *estuarine zone*, as an environmental system consisting of an estuary and those transitional areas consistently influenced or affected by water from an estuary, such as, but not limited to, salt marshes, coastal and intertidal areas, bays, harbors, lagoons, inshore waters and channels--as well as all or part of the mouth of a navigable or interstate river or stream or other body of water having unimpaired natural connections with open sea and within which the sea water is measurably diluted with fresh water derived from land drainage.

The total shoreline of the Gulf of Mexico includes 17,500 statute miles. Of this, some 4,000 miles have been categorized as recreation shoreline of which only 121 meet the criteria of public recreation shoreline. Of the slightly more than a thousand miles of recreation shoreline of the state of Texas, 301 miles are designated as beach, 421 bluffs, and 359 miles as marsh. For Louisiana with a comparable total shoreline 257 miles are designated as beach and the remainder of 819 as marsh. All but two miles of the entire 1,076 in Louisiana are privately owned. Of the total of 203 miles of shoreline for Mississippi, 134 are categorized as beach and 69 as marsh and 178 miles are privately owned.

The value of Louisiana fisheries in 1966 was approximately $100 million. In 1966, according to the Independent Petroleum Association of America, the value of crude oil, natural gas liquids, and natural gas at the well head, in Louisiana was slightly more than $3 billion and the petroleum industry paid almost half of the state's revenue.

Aquaculture is widely enjoyed in Asiatic countries and five percent of Japan's total fish catch comes from coastal areas having retention devices. Within the United States this is currently limited to development and pilot studies, but thriving commercial fresh water trout and catfish farms have developed recently. It is estimated that in the five-state southcentral region about 13,000,000 acres are suitable for conversion to catfish farms.

Port development expenditures in the United States from January 1, 1946 to December 31, 1965 in the Gulf Coast area totaled $385 million of which $199 million

was for general cargo facilities and $186 million for specialized facilities. During this period the average size tanker in the world fleet increased from 15,000 dead weight tons to 27,000. However, the majority of new tankers building and planned are much larger with the largest one now operating of 312,000 tons was built in Japan. Similar increases in size for dry bulk and container carriers are also forecast. Tankers having a tonnage of 760,000 tons have been forecast for 1980 and the uppermost practical limit of a million tons based upon projected technology and experience is forecast for the period between 1990 and the year 2000. Bulk carrier tonnage of 185,000 tons are forecast for 1980 and 317,000 tons for 1990.

Since the River and Harbors Act was passed in 1826 the Federal Government has assisted in the development of over 500 commercial harbors, as well as assuming the responsibility for periodic dredging maintenance and navigational aids such as charting, channel markers, and buoys. This has resulted during this period of expenditures totaling $2.2 billion of which approximately three-quarters has been for deep draft harbors and channels. Deep draft being defined as an authorized depth of 30 feet or more for coastal harbors. The Gulf Coast participated in this expenditure in the amount of $182 million for construction and $125 million for maintenance. For harbors less than 30 feet the total expenditures for this area has been $45 million. Non-federal contributions for these activities totaled $3¾ million for the shallow harbor class and $30 million for the deep.

Current funding by Federal agencies for activities relating to the Coastal Zone for the fiscal year averaged slightly more than $600 million. It involves such activities as fisheries, water pollution control, geologic surveys, national park services, Office of Saline Water, Bureau of Outdoor Recreation, Coast Guard, Corps of Engineers, ESSA, and so forth.

The suggested cost estimate for managing the Coastal Zone proposed by the President's Commission on Marine Resources is summarized in Table 2, for the next ten years in five-year increments. The total cost for the various categories including management and planning, land acquisition, scientific and engineering studies, including a Great Lakes restoration project, is estimated to be an average of $86 million annually for the first five years of the next decade, and $121 million per year for the next five years or a total of a little more than a billion dollars for the 1970 decade.

TABLE 2. Managing the Coastal Zone

(Incremental costs in millions of dollars)

	Average annual costs		Total 10-year costs
	1971-75	1976-80	
Management and Planning	$10	$10	$100
Land Acquisition	11	11	110
Scientific and Engineering Studies	50	80	650
Operation of Coastal Laboratories	10	20	150
Estuarine Monitoring Equipment	6	4	50
Pollution Research	4	2	30
Coastal Engineering and Technology	20	40	300
Ecological Studies	10	14	120
National Project--Lake Restoration Project	15	20	175
Total, Managing the Coastal Zone	86	121	1,035

COASTAL ZONE MANAGEMENT--PROBLEMS AND THEIR POSSIBLE SOLUTION

Currently federal, state, and local governments including intrastate and municipal coastal and harbor authorities are funding coastal zone facilities through revenues derived by taxation of citizens and industries situated in this area. Consequently, they also share the responsibility to develop a plan for the coastal zone which reconciles, or if necessary, must make decisions to choose among competing interests and protect both long- and short-term values. Effective management to date has been thwarted by:

1. the variety of government jurisdictions from all categories involved,
2. the low priority afforded marine matters by state governments,
3. the diffusion of responsibilities among state agencies, and
4. the failure of state agencies to develop and implement long-range plans.

Until rather recently, navigation over which the Federal authority is preeminent has tended to dominate other uses of the coastal zone and perhaps for this reason states have been slow to assume their full responsibilities. In addition, the Federal role in the Coastal Zone has grown haphazardly and unfortunately with a minimum of coordination among the agencies responsible. For example, closely related functions are discharged by the U.S. Coast Guard, Army Corps of Engineers, Department of Housing and Urban Development, together with a number of bureaus of the Department of the Interior and several other Federal agencies. The Federal Government sponsors planning activities in certain coastal areas through River Basin commissions, which were established pursuant to Title II of the Water Resources Planning Act of 1965 and in certain others to regional commissions established under Title V of the Public Works and Economic Development Act.

Current coordination at the Federal level is the Committee on Multiple Use of the Coastal Zone of the Marine Council. It considers the broad aspects of coastal management and seeks effective and consistent Federal policies. In addition, the Water Resources Council, a Cabinet level coordinating and planning group analogous to the Marine Council, but chaired by the Secretary of the Interior also has an interest in the Coastal Zone. However, its work is primarily directed to inland waters, but neither committee is concerned with the detailed management of specific coastal areas. This diffusion and fragmentation of responsibility is reflected within state governments within which individual agencies deal directly with their counterparts at the Federal level. Too often states lack plans of their own based on an appraisal of all state interests and a lack of sound scientific knowledge in developing and maintaining their coastal resources. Frequently, in these cases states have tended only to react to Federal plans.

On a state government level, the states are frequently subjected to intense pressures from the county and municipal levels because coastal management often directly affects local responsibilities and interests. Hence, local knowledge frequently is necessary to reach rational management decisions at the state level. These decisions in turn should be reflected at the Federal level. Thus, making it necessary to reflect the interests of local governments in accommodating competitive needs.

The President's Commission on Marine Engineering and Resources has given considerable thought to the problem of Coastal Zone Management. It recognized the tremendous significance of this problem by designating a panel to study it specifically during its two-year tenure. In fact, of the many recommendations made by the Commission to accelerate the development of marine resources the closest program considered for the possible category of a crash program was that of Coastal Zone Management. This is necessary because of the rapidly accelerating rate at which existing coastal zone areas are being consumed for a variety of purposes, without any long-term planning or often recognizing the legitimate needs of competing uses both industrial and sociological. As a result of the studies of this Commission panel,

as well as of the entire membership a number of specific recommendations have been made. Some of the major ones include:

1. A coastal management act be inacted to provide policies and objectives for the coastal zone, and authorize federal grants-in-aid to facilitate establishing state coastal zone authorities empowered to manage the coastal waters and its adjacent land.

2. Federal legislation to aid states to establish coastal zone authorities should not impose any particular form of organization. But it should require approval of each grant be contingent on showing that the proposed organization has the necessary powers to accomplish its purposes, has broad representation, and provide adequate opportunities to hear all viewpoints, before adopting or modifying its coastal development plans.

3. The land and water conservation fund be more fully utilized to acquire wet lands and potential coastal recreation lands. Enact legislation authorizing federal guarantees of state bonds for wetland acquisition when necessary to implement the coastal management plan.

4. All federal agencies providing grants-in-aid to states, or engaging in coastal activities should review all projects for consistency with plans by the state coastal zone authority.

5. Estuarine studies should be conducted by the Department of the Interior to identify areas to be set aside as sanctuaries to provide natural laboratories for ecological investigations.

6. Federal and state agencies with coastal zone responsibilities should provide more adequate support for scientific and engineering research on coastal problems. This includes making an inventory of the multiple resources in this area.

7. Universities affiliated with coastal laboratories should be encouraged to provide aid to state officials on coastal issues and for their training.

8. The National Oceanic and Atmospheric Agency in collaboration with the Department of Transportation, U.S. Army Corps of Engineers, and the Atomic Energy Commission should support feasibility and fundamental engineering studies relevant to the development of offshore terminals, storage facilities, and nuclear power plants.

9. Legislation be enacted to enable the AEC to consider environmental effects of projects under its licensing authority.

10. Rivers and Harbors Act of 1899 be amended to empower the U.S. Army Corps of Engineers to deny a permit in order to preserve important recreation, conservation, or esthetic values, or to prevent water pollution.

11. The FWPCA should give increased emphasis on research to identify specific pollutants and their effects. Immediate action by this agency aided by the National Oceanic and Atmospheric Agency should be taken to develop instrumentation and to detect and record pollution loads as part of an overall estuarian monitoring network.

12. Review enforcement procedures by federal agencies to strengthen enforcement of existing laws, and Presidential orders concerning pollution abatement.

13. Federal assistance should be given to states and localities adequate to permit the construction of waste treatment facilities at the rate already authorized by law.

The Commission recommended also that coastal zone policies should recognize the desirability to provide an outlet for the energy and innovative talent of individual entreprenures. Many ways exist in which these energies might be applied including not only for aquaculture projects but for underwater tourism. States should develop procedures to permit the leasing of offshore areas for new uses consistent with the overall plans of the state coastal zone authorities to develop these areas.

It was felt by some that underwater leases of this type might capture some of the excitement and public interest spurred by the Homestead Act of 1862. Such "sea-steads" might be offered for extended periods on attractive terms contingent upon the useful development of the marine tract so that it would still safeguard necessary navigation, fishing, and other uses of the superjacent waters, and would also be integrated for the overall plan for the development of the Coastal Zone. In this connection, it should be emphasized that oil, gas, and mineral rights could not be conveyed through a seastead plan.

Estimated costs of the various facets necessary for a comprehensive, efficient, and successful plan to manage the Coastal Zone were summarized in Table 2. It is not too soon to start implementing the many recommendations made by the Commission for the Coastal Zone of the United States, which is the Nation's most valuable geographic feature if it is to be developed in an optimum manner for all concerned. Yet it must be done in a manner compatible for the best short- and long-term interests of the diversified segments of the industrial and sociological components of our society. Otherwise it will not be possible to cope successfully with the myriad of problems involved in this area which holds for our nation so much promise, as well as unfortunately problems. Hopefully, the latter will not be insurmountable if the entire Nation is to derive the maximum benefit from this area.